Project ID# eems057
Pillar(s): Urban Science

U.S. DEPARTMENT OF ENERGY
SMARTMOBILITY
Systems and Modeling for Accelerated Research in Transportation

Urban Traveler – Changes and Impacts: Mobility Energy Productivity (MEP) Metric

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DOE Vehicle Technologies Office
2019 Vehicle Technologies Office Annual Merit Review
June 11, 2019

Argonne NATIONAL LABORATORY
INL Idaho National Laboratory
BERKELEY LAB
OAK RIDGE National Laboratory
NREL NATIONAL RENEWABLE ENERGY LABORATORY

OVERVIEW

Timeline

- Project start date: 10/1/2017
- Project end date: 9/30/2019
- Percent complete: 70%

Budget

- Total project funding
  - DOE share: $850K
  - Contractor share: $0
- Funding for FY 2018: $350K
- Funding for FY 2019: $500K

Barriers

- Lack of open and practical metrics to quantify energy productivity of mobility
- Need for new tools & core capabilities to determine the value and productivity derived from new mobility technologies

Partners

- SMART Mobility Laboratory Consortium:
  - Argonne National Laboratory (ANL)
  - Lawrence Berkeley National Lab (LBNL)
- American Society of Civil Engineers (ASCE)
- Colorado Department of Transportation (CDOT)
- Ford Motor Company
- Dallas Fort worth International Airport

BACKGROUND

- What is mobility?
- How do you quantify mobility?
  - No “open” and practical method to quantify mobility
- Existing transportation performance metrics only measure utilization or efficiency of road network
- Can we increase energy efficiency if we connect people better?
- Productivity = Mobility Benefits/Costs

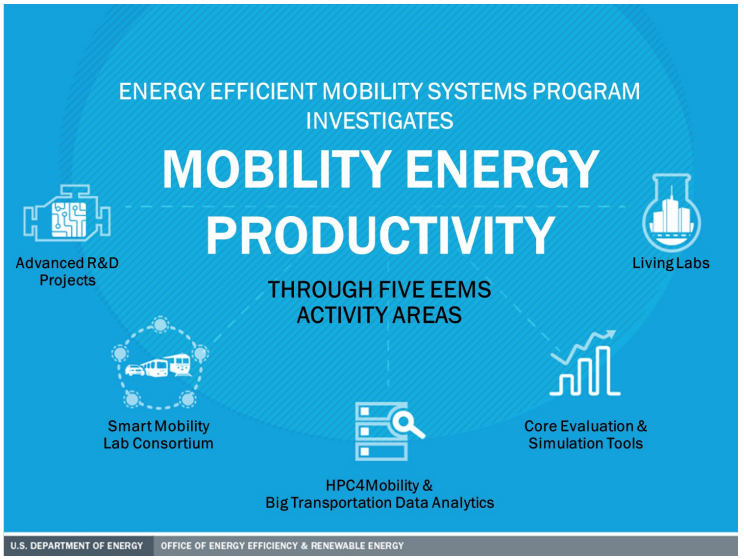
Mobility: The quality of a network or system to connect people to goods, services, and employment that define a high quality of life.

“From MPG to Mobility per Gallon”

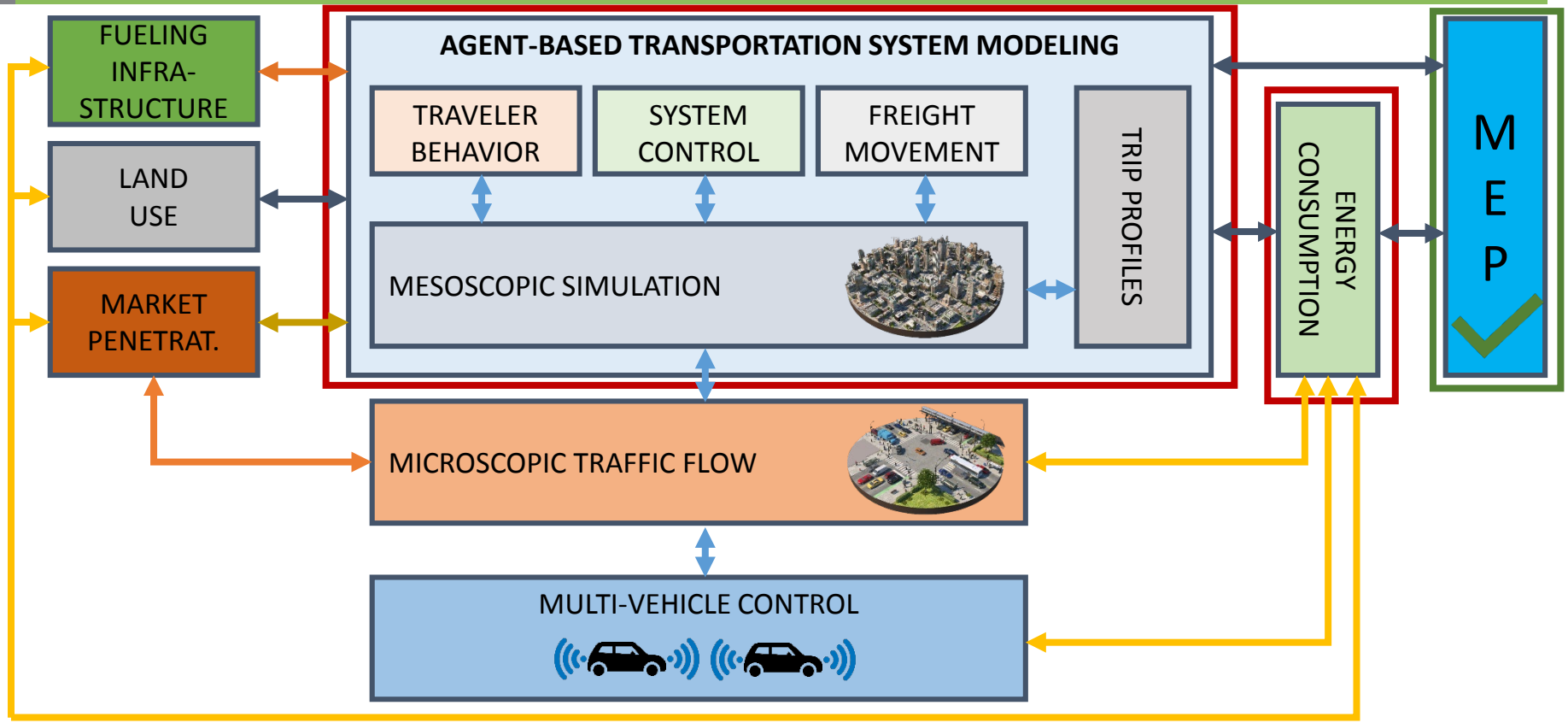
“Optimizing mobility – while minimizing energy”

RELEVANCE

- **Overall Objective**
  - To create a scalable open-source metric to quantify and compare energy productivity of mobility options provided by existing and emerging transportation options.
- **Objectives this period**
  - Comprehensive literature review on existing accessibility and travel–energy–quantification metrics.
  - Development of an operational open source code for the metric and a comparative analysis across different cities and scenarios.
  - Develop a framework for integration with POLARIS and BEAM models.
  - Solicit feedback from academia and industry sources on the metric.
- **Impact**
  - This metric serves as a unified lens through which research in the DOE–EEMS portfolio can be assessed.
  - Being considered as a metric for the ASCE SMART City standard.



RELEVANCE: RELATIONSHIP TO WORKFLOW MODELING



The MEP metric will capture the impact of emerging technologies and land use patterns on accessibility - including impacts on travel time, energy usage, and the cost of different modes of transportation.

MILESTONES

Month/Year	Description of Milestone or Go/No-Go Decision	Status
February 2018	Report, *Literature Review on Accessibility Metrics*	Complete
June 2018	Technical report on the methodological framework to estimate a comprehensive accessibility metric	Complete
January 2019	Development of an open source software package to implement the MEP calculation procedure	Complete
April 2019	Integration of MEP open source package with agent-based travel models POLARIS and BEAM	Complete

APPROACH: TASKS

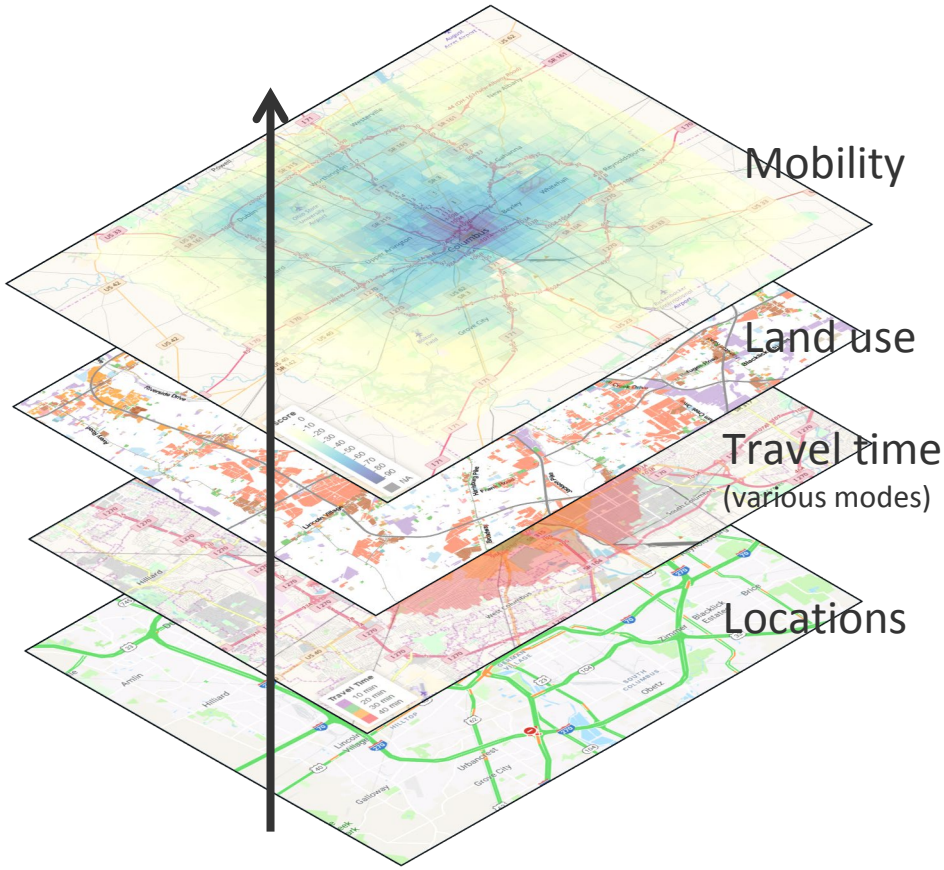
Name	Description
Methodological enhancements and application to 50 metro areas in the U.S.	Enhancing the MEP calculation procedure with population weighting. Inclusion of transportation networking company (TNC) and paratransit modes. Conducting additional scenario analyses Applying the MEP metric in top 50 metropolitan areas in the US.
Integration with workflow scenario runs	Development of a MEP module that can be used either in standalone mode (with existing data sources) or integrated with travel models such as POLARIS and BEAM. Efforts will focus on developing a unified framework for ingesting outputs from BEAM or POLARIS and computing MEP.
Outreach	As a part of this task, MEP updates will be presented to the SMART research community on a quarterly basis. Working with ASCE to develop MEP as an ASCE Smart City Standard.

APPROACH: PROPERTIES OF A GOOD MEP METRIC

- Reflects efficiency of accessing a variety of goods, services, and employment opportunities
- Based on established/accepted research, yet supportable by available data
- Can be applied to any mode (car, walk, bike, transportation network company (TNC), etc.)
- Determined by:
  - Travel time as well as travel time reliability to destinations
  - Energy and monetary cost of travel
- Spatially scalable (applied to a home, district, city, employer)
- Can compare:
  - Two locations (e.g., Topeka, Kansas vs. Chicago, Illinois)
  - Two planning strategies (e.g., roadway extension vs. transit expansion)
  - Two technologies (e.g., electric vehicle penetration vs. automated vehicle penetration)

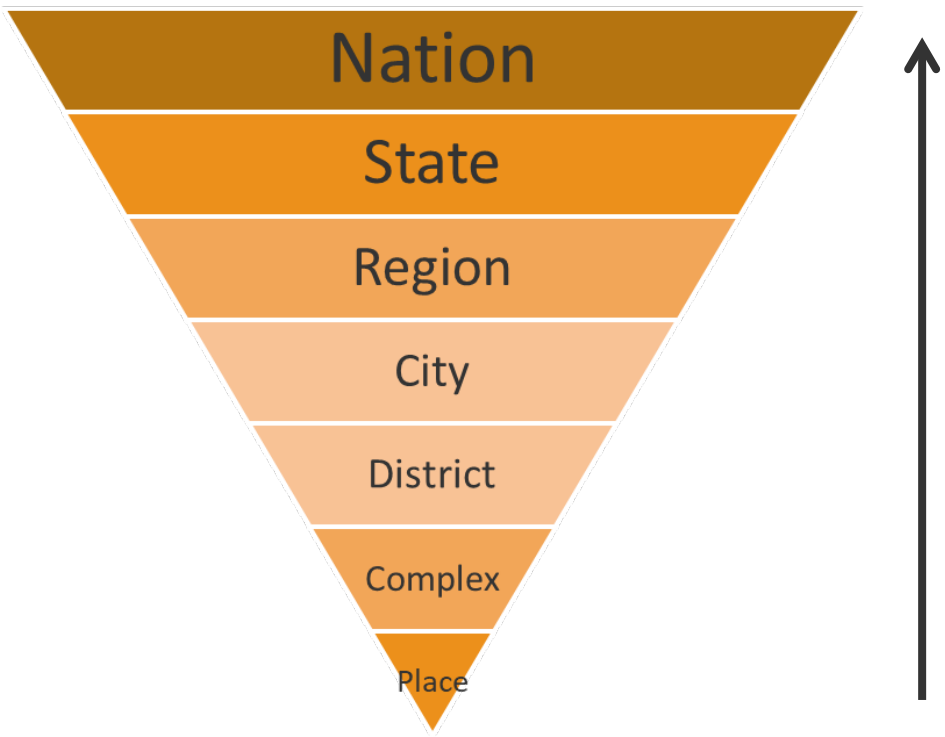
APPROACH: CONCEPTUAL DEVELOPMENT OF MEP METRIC

- Many “siloed” metrics, such as walk score, bike score, transit score, and average travel time index (by auto) are available to understand the mobility of a neighborhood
- Effectively combine different modes into a holistic metric
- Incorporate the energy and cost components as well as land use information into the metric



Mobility-Energy Productivity Metric = *F* (mobility weighted by [energy, cost, trip purpose])

APPROACH: CONCEPTUAL DEVELOPMENT OF MEP METRIC

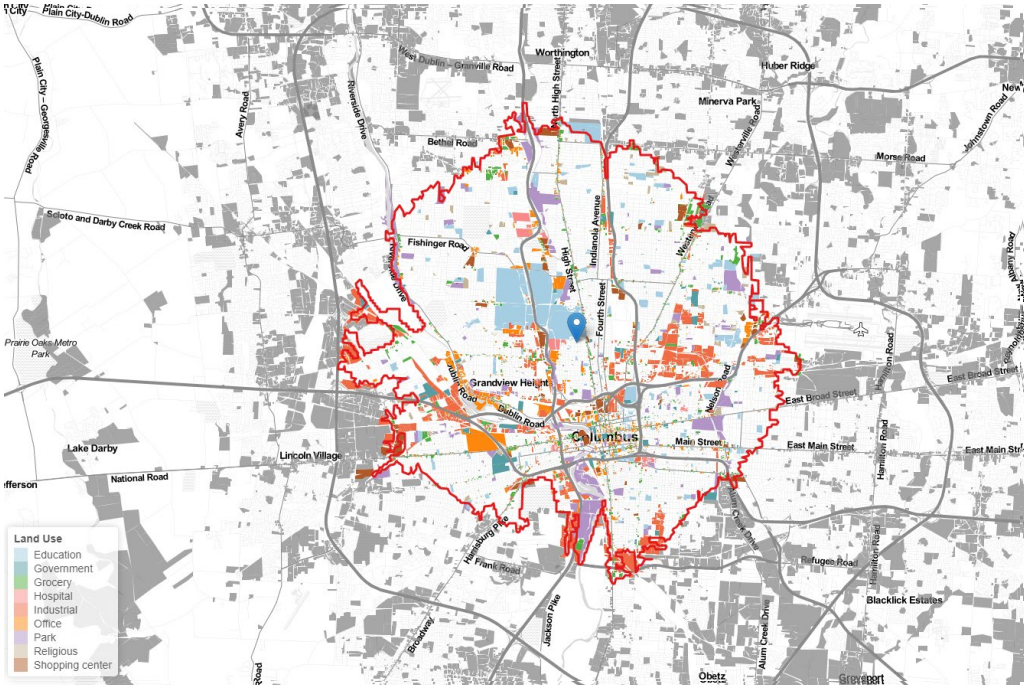


A metric that is easy to scale spatially, as different contexts might need the metric computed at different scales.

- The MEP metric can be customized by different weighting parameters at the local level (activity distributions in Columbus might be different from those in Chicago), and then aggregated by population
- Can be disaggregated by geography, mode, trip type, and population sub-group

APPROACH: EXAMPLE OF AN ISOCHRONE

- Count the opportunities that can be accessed within a travel time of 10, 20, 30, and 40 minutes for every cell



A example of opportunities accessible by biking

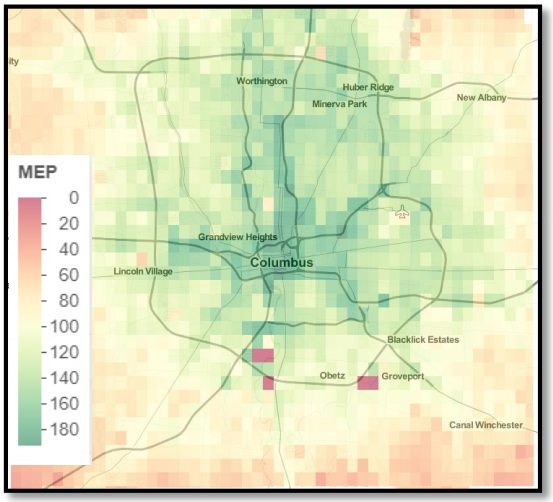
- Caveat: Walk and bike isochrones are constructed using highway network (with criteria selection for bikeable/non-bikeable roads), and average walk/bike speeds. Future iterations will consider incorporation of bike/ped infrastructure in computing isochrones.

APPROACH: BASIC DATA ELEMENTS OF THE MEP METRIC

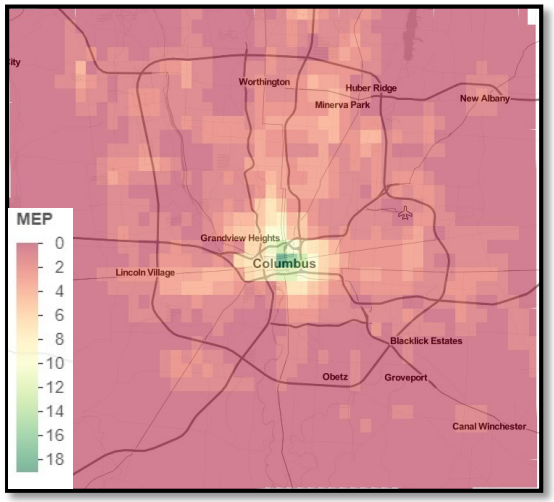
- Quantify the number of opportunities that people can reach within a certain travel time threshold via different transportation modes

- The opportunities measure is weighted by the energy and cost-efficiency metrics of different transportation modes, as well as frequency of engaging in different types of activities.

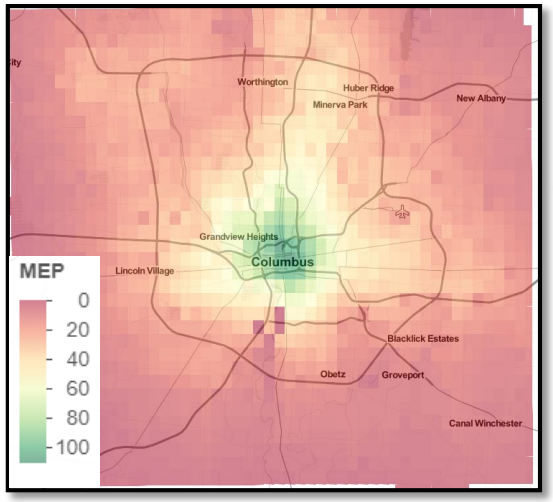
TECHNICAL ACCOMPLISHMENTS AND PROGRESS: MEP MAPS BY MODE (Columbus, OH)



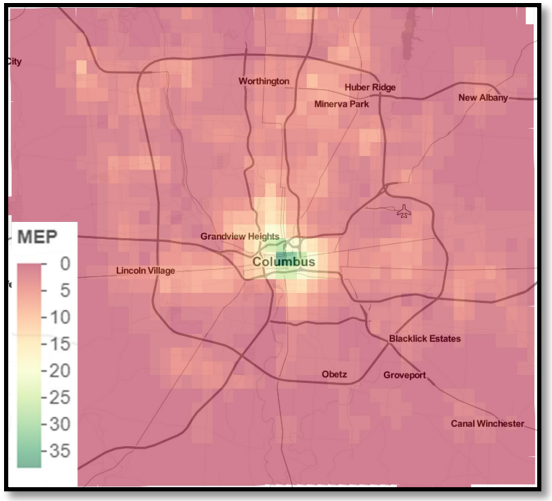
Driving



Transit



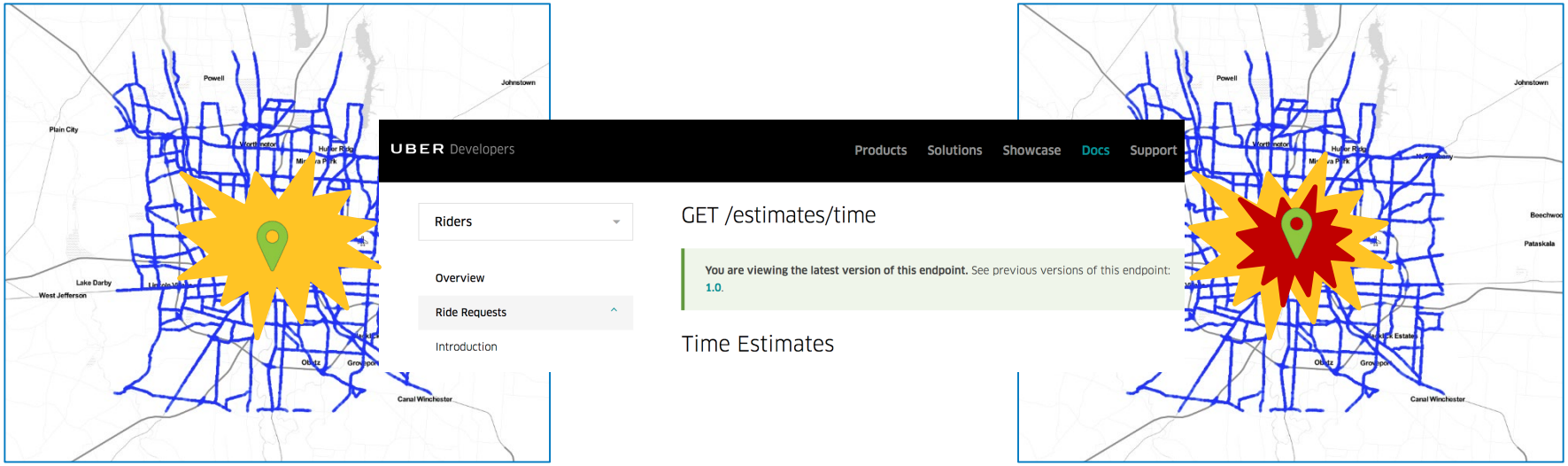
Bike



Walk

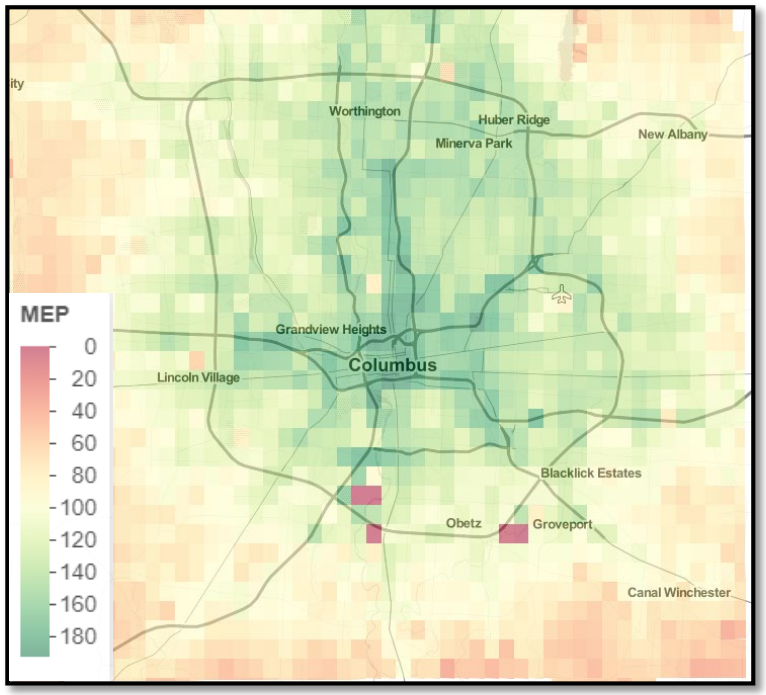
TECHNICAL ACCOMPLISHMENTS AND PROGRESS: TNC ISOCHRONES

- Isochrones of t minutes by TNC are assumed to be the isochrones of $t - t_w$ minutes by driving, where t_w is waiting time
  - Waiting times obtained from Uber's Application Programming Interface



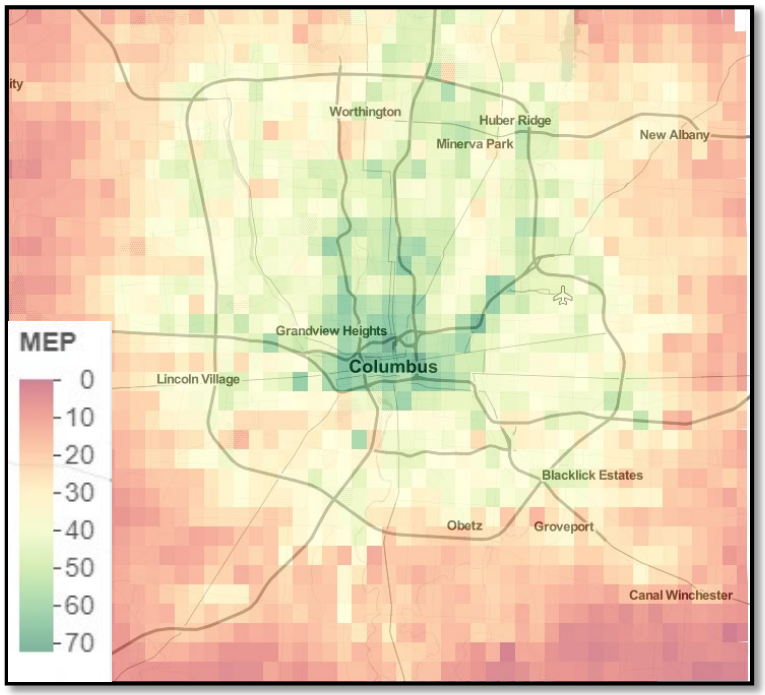
TECHNICAL ACCOMPLISHMENTS AND PROGRESS: TNC ISOCHRONES

Driving



Driving MEP: 126

TNC



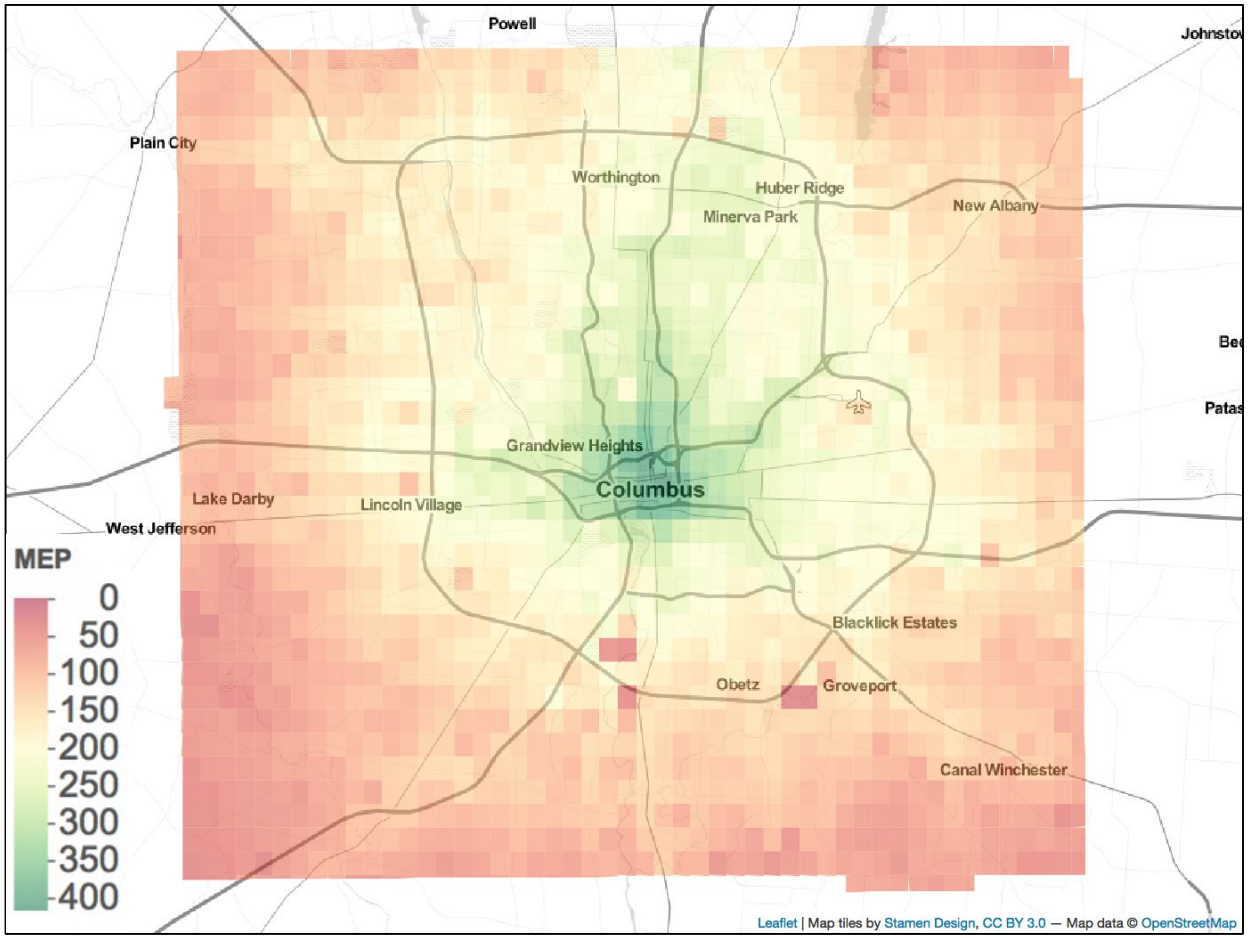
TNC MEP: 92 (27% Less than Driving MEP)

Caveats:

- TNC MEP is less than Driving MEP due to the impact of wait times
- The TNC MEP computation does not account for any secondary effects of TNCs such as increased travel or congestion effects.

TECHNICAL ACCOMPLISHMENTS AND PROGRESS: POPULATION-WEIGHTED MEP (Columbus, OH)

Population density weighted MEP metric: 198

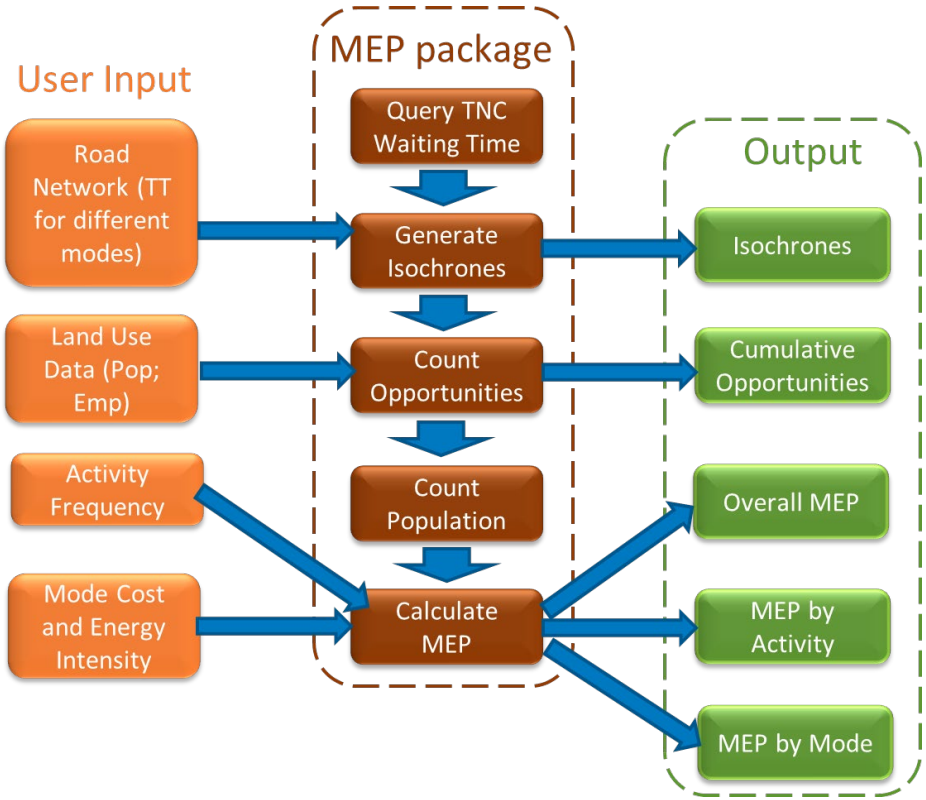


TECHNICAL ACCOMPLISHMENTS AND PROGRESS

- *American Society of Civil Engineers (ASCE)* is adopting the MEP Metric as one of six proposed metrics to measure SMART City improvements
  - A memorandum of understanding is underway
- In discussions with *Colorado Department of Transportation (CDOT)* to integrate the MEP metric into the statewide travel model for Colorado
- **Technical Report:** Literature Review on Accessibility Metrics
- **Journal article**, "A Novel and Practical Method to Quantify the Quality of Mobility: The Mobility Energy Productivity"
  - Presented at the 2019 Annual Meeting of the Transportation Research Board
  - Selected for publication in Transportation Research Record
- **Conference Paper**, "Measuring Fundamental Improvements in Sustainable Urban Mobility: The Mobility-Energy Productivity Metric"
  - Selected for presentation at the ASCE International Conference on Transportation & Development to be held in Reston, Virginia

TECHNICAL ACCOMPLISHMENTS AND PROGRESS

MEP Package Architecture for Integration with POLARIS and BEAM

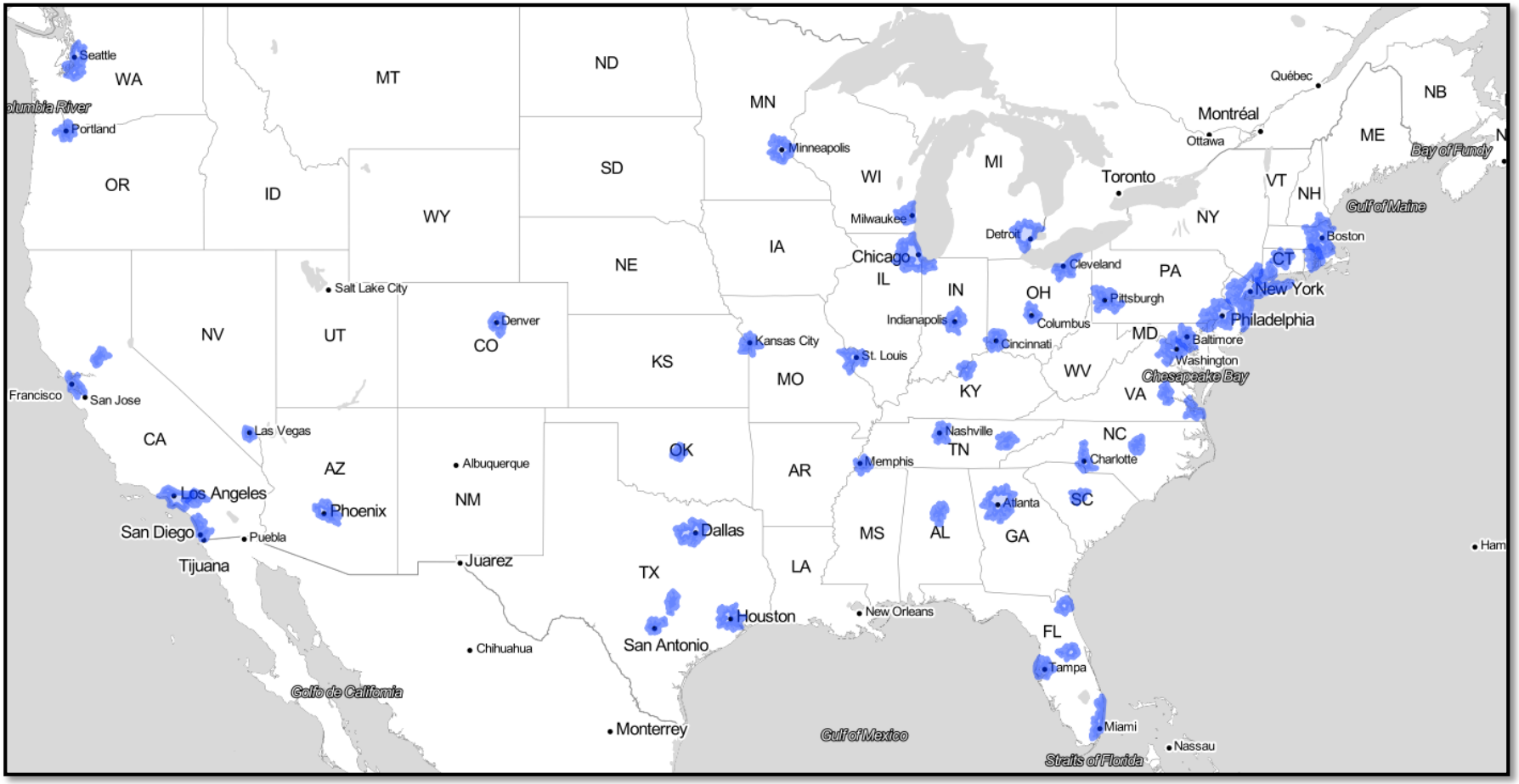


The MEP package is being utilized to quantify impacts of various workflow scenarios being run in POLARIS and BEAM

TT: Travel Time; Pop :Population; Emp: Employment

TECHNICAL ACCOMPLISHMENTS AND PROGRESS

Top 50 Metropolitan Areas in the United States to calculate MEP scores



RESPONSES TO PREVIOUS YEARS REVIEWERS COMMENTS

- No AMR review of MEP in FY 18, as it was a small project in April of last year.

COLLABORATION AND COORDINATION WITH OTHER INSTITUTIONS

- Aforementioned SMART Mobility Consortium Laboratory Partners:
  - LBNL, ANL, Idaho National Lab (INL) and Oak Ridge National Lab (ORNL)

- Additional Collaborations

Collaborators	Type	Extent
ASCE	Government	Designating MEP as a SMART City metric
CDOT	Government	Plans to integrate MEP into the Statewide Travel Model
Ford	Industry	Adopt and enhance the MEP metric
Strategic Priorities and Impact Analysis Team (SPIA)	DOE	Correlating MEP metric with other transportation related measures
Dallas/Fort Worth International Airport	Industry	Adopt MEP in the context of airports
ORNL	DOE	MEP computation for Chattanooga region
University of Maryland, Carnegie Mellon, and Colorado State University	University	Adopting MEP in various contexts

REMAINING CHALLENGES AND BARRIERS

- Data availability on upcoming and future modes continues to be a challenge
  - Observable as well as unobservable data, such as perception of travel time in a chauffeured or automated vehicle

- Computational requirements hinder real-time calculations (or continuous updates) to MEP metric calculation
  - High-performance computing (HPC) implementation of MEP calculation procedures is currently underway

- More research is required to address the handling of modal integration, variation in socio-demographics, and employer MEP perspective
  - Moving towards an individually customizable MEP

PROPOSED FUTURE RESEARCH

- How does the MEP metric correlate with other transportation metrics in a region?
  - Research currently underway through an effort funded by the Strategic Priorities and Impact Analysis Team (SPIA)
- How to quantify mobility improvements from specific projects without relying on advanced travel models
  - Use of machine learning for predicting MEP based on a "future" state
- How to customize MEP calculations for individual specific socio-demographic and trip characteristics
- How to develop metrics that represent multi-modal and multi-leg trips (e-scooter – bus – walk)
- Extend the methodology to quantify MEP scores for significant travel generators/attractors such as universities, airports, or major employers
  - Airport customization of the MEP metric being carries out as a part of the ATHENA (Advancing Transportation Hub Efficiency using Novel Analytics) project.

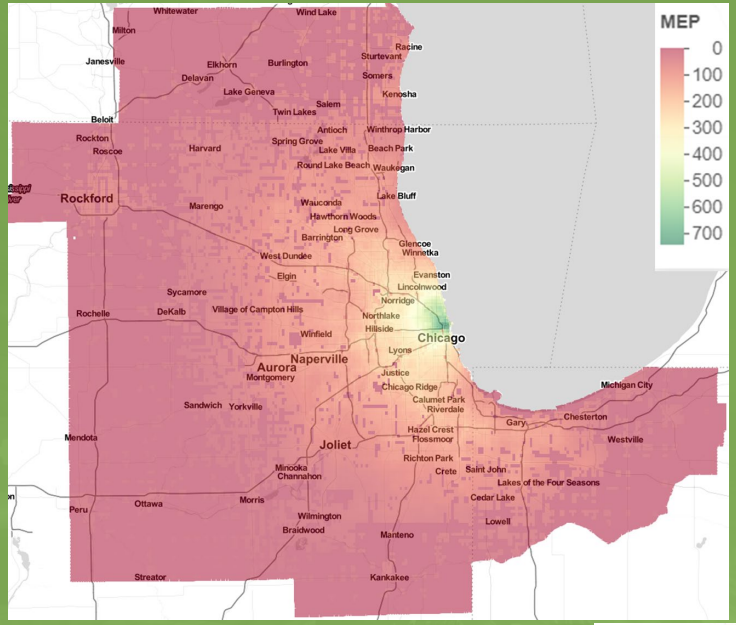
"Any proposed future work is subject to change based on funding levels."

SUMMARY SLIDE

- **OBJECTIVE:** To develop a comprehensive metric that provides a way to measure the quality of mobility, taking time, energy, and cost of modes into consideration. Such a metric will not only help quantify mobility in the current day, but also provide an avenue to measure improvement in mobility with time and/or technological advancement.

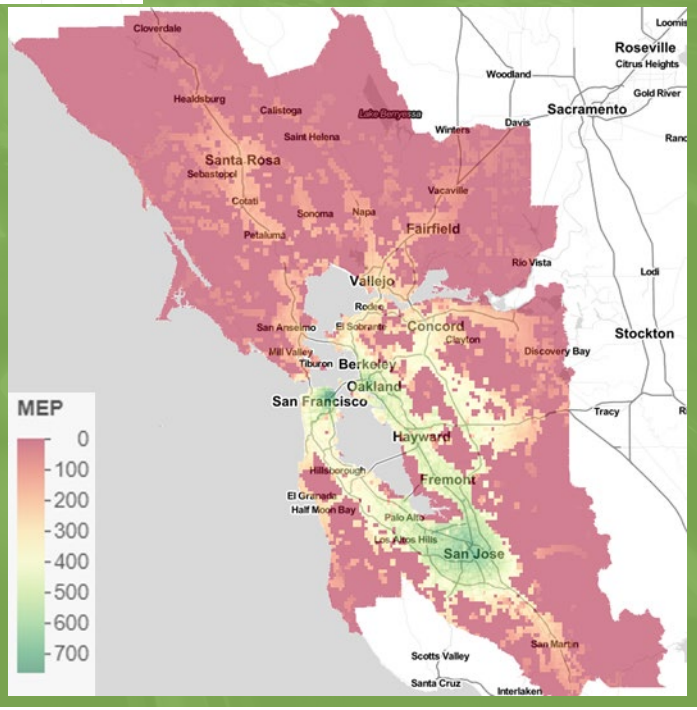
- **FY18** efforts focused on developing methodology as well as an open-source software module that can be integrated into travel models, which will aid in scenario analyses.
  - ASCE is designating the MEP metric as a SMART City measurement standard
  - CDOT is considering integrating this metric into its statewide travel model

- **FY19** efforts are focusing on:
  - Enhancing the methodology
  - Tightly integrating with POLARIS and BEAM, and developing a generic plug-in module (akin to EPA MOVES package) to work with outputs from any travel demand model.
  - Applying the metric to 50 metropolitan areas across the United States.



Next Up

QUESTIONS?



TECHNICAL BACK-UP SLIDES

APPROACH

- Literature review
- Identify gaps in existing accessibility research

- Address the gaps by developing a metric that considers accessibility, energy, and affordability of travel
- Define properties of a comprehensive MEP metric

- Develop a metric with desirable properties

Breadth Application: Apply the MEP metric to multiple cities across the United States for a comparative analysis

Depth Application: Integrate the MEP metric into sophisticated travel models to investigate impacts of technological advancements on Mobility Energy Productivity

DATA SPECTRUM DRIVING THE METRIC

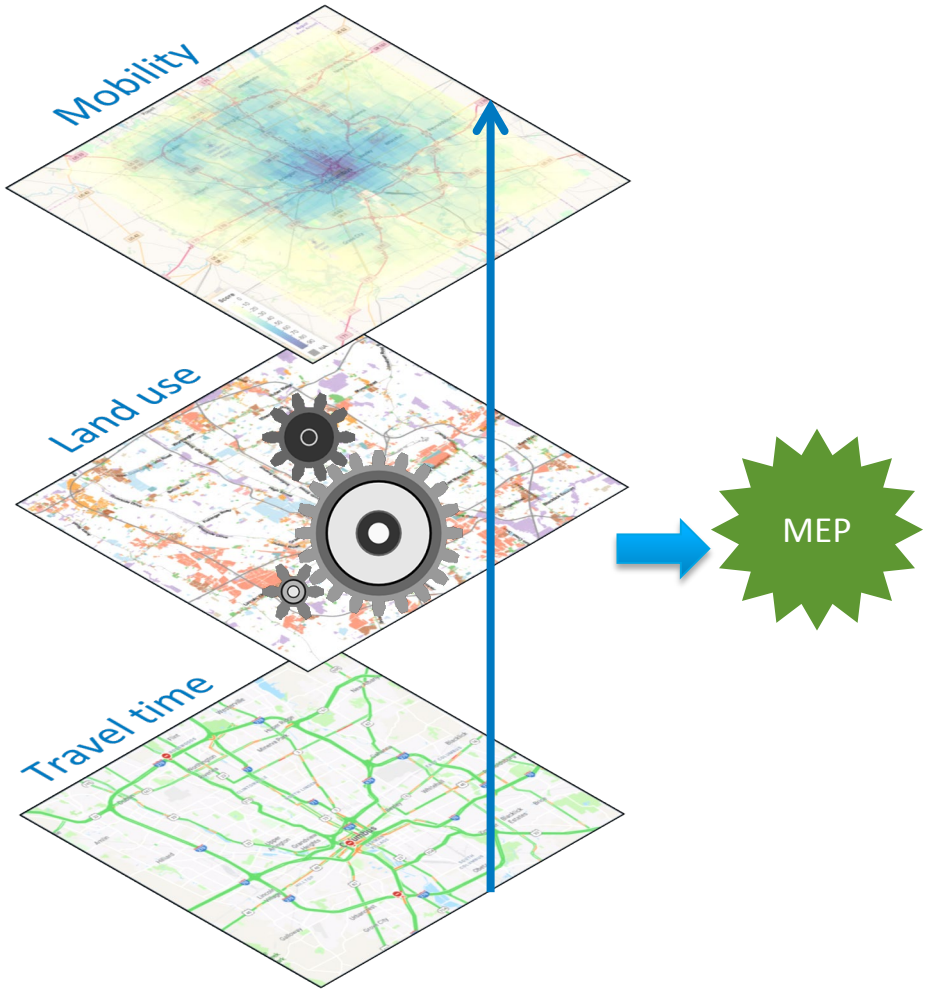
Travel Time and Isochrone
- Third party isochrone APIs (e.g., HERE)
- GPS trajectory data (TomTom, INRIX)
- Travel Demand Models

Land Use Data
- Metropolitan Planning Organizations

Energy Efficiency Measures
- Transportation Energy Data Book
- Other energy intensity studies

Travel Demand Data
- National Household Travel Survey (NHTS)
- Travel models

Cost Measures
- Capital costs, operational costs
- Value of time



MEP MAPS BY ACTIVITY – COLUMBUS, OH